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EDIACARAN SHURAM EXCURSION INTERPRETED, REINTERPRETED, AND MISINTERPRETED

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Since the earliest report of the Ediacaran Shuram excursion (SE) almost 30 years ago, the origin of this negative carbon isotope ($\delta^{13}C$) anomaly has been hotly debated. Numerous hypotheses have been proposed, ranging from primary to diagenetic, from local to open ocean signals. As yet, no consensus has been reached. Recently, we applied secondary ion mass spectrometry (SIMS) to study SE carbonates at intra-shelf (Jiulongwan) and outer-shelf (Zhongling) sections of an Ediacaran rimmed basin in South China.

Our investigation shows that diagenesis of the SE at Jiulongwan is mainly limited to neomorphism and dolomitization. Coupled SIMS analysis consistently shows $\delta^{13}C$ of ~–8‰ in both the micritic matrix and secondary dolomite crystals. The mean values of SIMS $\delta^{13}C$ data measured from the matrix and secondary dolomite are statistically indistinguishable within each sample, suggesting sediment-buffered diagenesis of $\delta^{13}C$. Importantly, no positive $\delta^{13}C$ or any extensive dissolution-cementation texture has been found. These results suggest a depositional or fabric-retentive early authigenic origin for the SE, and argue against previously published hypotheses that the SE was caused by meteoric water diagenesis or late burial diagenesis.

We also revisited the Zhongling section and discovered remarkable μm-scale heterogeneity of $\delta^{13}C$ in authigenic calcite cements, with extremely negative values down to –37.5‰. We interpret these cements as methane-derived authigenic calcite resulting from microbial sulfate reduction and anaerobic oxidation of methane during deposition.

We propose that variation of the SE — a notable phenomenon that has been reported in many basins — was modulated by methane oxidation under variable local redox and water depth conditions. The SE likely reflects local carbon cycle anomalies coupled with different degrees of methane oxidation in individual Ediacaran basins and globally triggered by enhanced seawater sulfate and marine transgression during an atmospheric oxygenation event. Our study demonstrates that previously published hypotheses that argue for a post-depositional origin for the SE can be tested by fabric-specific in situ analysis in a detailed petrographic context.

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